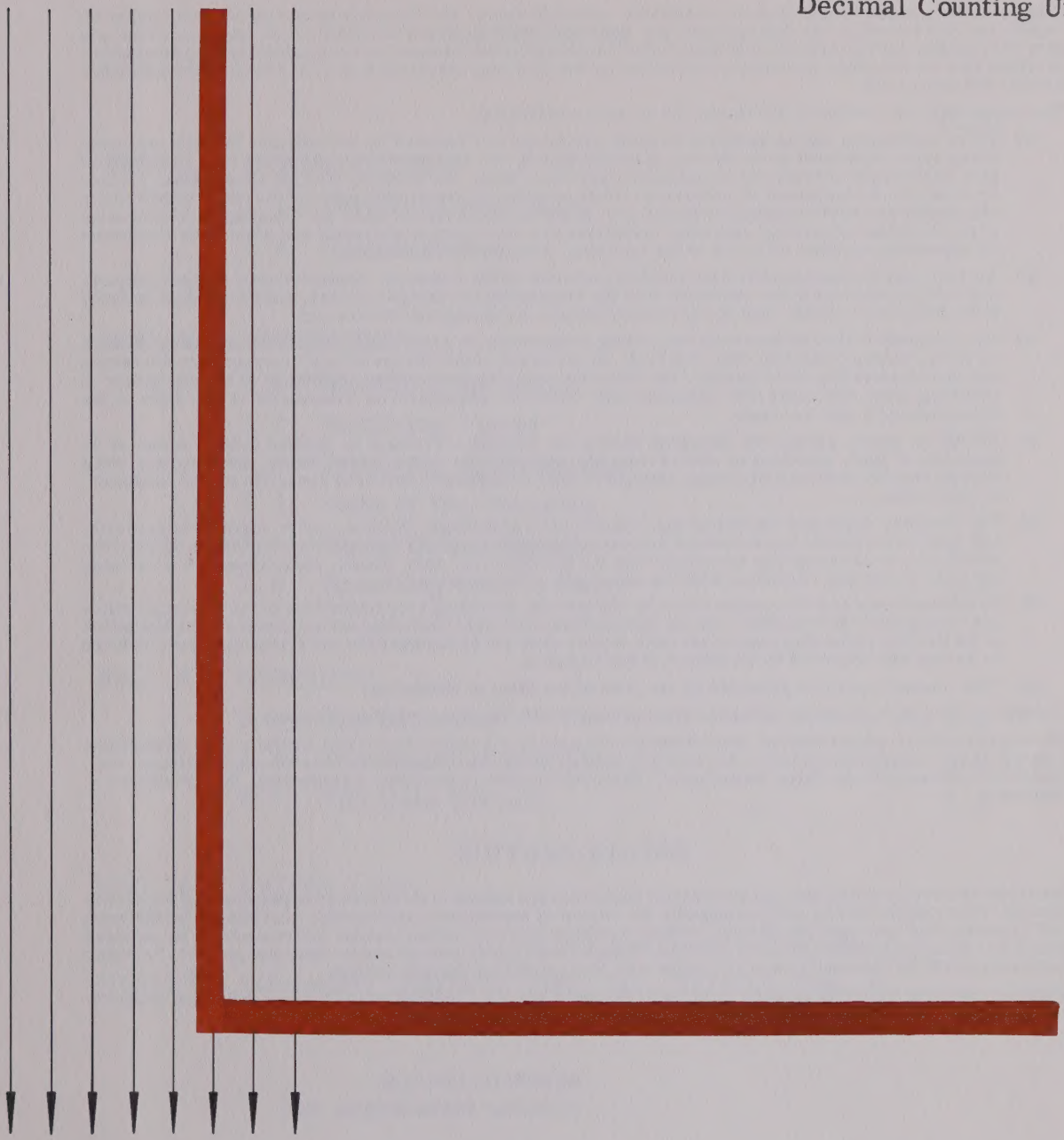
INSTRUCTION MANUAL

MODEL 872
Decimal Counting Unit



Beckman® INSTRUMENTS, INC.

BERKELEY DIVISION
2200 Wright Avenue
Richmond, California

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WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

(a) Some components and accessories by their nature are not intended to, and will not, function one year. If any such component or accessory manufactured by the Company and part of the item sold fails to give reasonable service for a reasonable period of time, the Company will, at its election, replace or repair such component or accessory. What constitutes reasonable service and what constitutes a reasonable period of time shall be determined solely by the Company after the Company is in posession of all the facts concerning operating conditions and other pertinent factors and after such component or accessory has been returned to the Company, transportation prepaid.

(b) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect, unless the item is found to be defective in which case the Company will pay all transportation charges.

(c) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.

(d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

(e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.

(f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.

(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

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Model 872 Schematic Diagram, Dwg. No. D416913-Rev. B

SECTION 1

INTRODUCTION

1.1 GENERAL DESCRIPTION

The Model 872 DCU is a plug-in electronic counting unit using solid state components mounted on a printed circuit board. The unit provides a count of input pulses from zero to nine, each count being represented by output signals in 1-2-4-8 binary-coded decimal form. With a Data Storage Unit (DSU), this binary-coded decimal output can be converted into a decimal digit display of the registered count.

At every tenth input pulse the DCU generates an output signal that can be used to drive a Model 862 DCU. Thus, any number of these units can be cascaded (the output of one connected to the input of the next) to form a counter whose total count capacity depends only on the number of DCU's.

Since each DCU generates one output pulse for every ten input pulses, these units can also be used as decade frequency dividers.

1.2 SPECIFICATIONS

See Table 1-1.

Table 1-1

Input Requirements	Positive pulse 0.7 volt minimum to 1.0 volt maximum amplitude from a source impedance of 180 ohms or less. Pulse duration of 10 nanoseconds minimum, 20 nanoseconds maximum.
Counting Rate	0 - 50 mc.
Count Indication	Use with DSU for visual indication of stored count.

continued. . .

Table 1-1 - continued

Output Characteristics	1) 1-2-4-8 permuted binary code. 2) Emitter-follower output with 1.5KΩ emitter resistance to -15 volts. 3) Carry pulse designed to drive a following Model 862 or 850 DCU. 4) One output is available from each binary: -0.2 volt for binary 1, -6.0 volts for binary 0. Each binary will supply 2 ma to the DSU.
Gating Requirements	10 to 30 ma, depending on amplitude of input pulse, required to inhibit counting.
Transfer Time	15 nanoseconds between application of 10th input pulse and start of output pulse.
Reset to Zero	Accomplished by negative pulse or voltage level change. Reset line held at 0 volts. At reset, line is driven to -10 volts for 1 microsecond, minimum.
Power Requirements	100 ma at -15 volts, and 7 ma at +10 volts.
Operating Temperature	-20°C to +65°C.
Construction	Etched wire module with circuitry on both sides using "plated-through" component holes.
Transistors	Four specially selected, high speed switching units: four 2N961, two 2N709, soldered into circuit.
Dimensions	1/2" wide, 3-11/16" high, 3-5/32" deep.
Weight	1-3/4 oz.
Connector Required	Typical: Ucinite 119510-MC-15C. Beckman Stock No. 680-815353.

SECTION 2

OPERATION

2.1 MOUNTING THE UNIT

The DCU plugs into a 15-pin printed-circuit card connector Typical connector: Ucinite 119510-MP-15C.

2.2 SUPPLYING POWER

The unit operates with supply voltages of -15 volts and +10 volts. The negative voltage supply connects to pin K of the DCU connector, while the positive supply connects to pin J.

2.3 SUPPLYING INPUT SIGNALS

Connect the source of input signals to pin A of the DCU connector. The unit will register a count each time a pulse meeting the requirements listed in Table 1-1, Input Requirements, is applied to the input terminal Gate current is applied to pin C.

2.4 STATE OF THE BINARIES

At the collectors of the "normally-on" transistors, -6.0 volts indicates the corresponding binary is in the "one" state, while -0.2 volt represents the "zero" state. Table 2-1 indicates the binary states for each registered count from 0 to 9.

Use Table 2-1 to convert a coded digit to a decimal digit. Note the weight of each column in which a "1" appears, then sum the weights. For example, the coded digit "1100" is equivalent to 1+2+0+0 = 3; and "1001" is equivalent to 1+0+0+8 = 9.

2.5 USING OUTPUT SIGNALS

The unit provides readout signals in the form of high and low potentials at terminals D, F, M, and P of the DCU connector. These signals can be used to drive any external load within the specifications listed in Table 1-1, Output Characteristics.

For example, the readout signals at terminals D, F, M, and P can be used to drive a Data Storage Unit for a visual indication of the registered count. In addition, the output signal supplied to terminal R each time the count goes from 9 to 0 can drive a Model 862 or 850 DCU.

Table 2-1. State of the Binaries

DECIMAL DIGIT REGISTERED	FIRST BINARY STAGE (Weight 1)	SECOND BINARY STAGE (Weight 2)	THIRD BINARY STAGE (Weight 4)	FOURTH BINARY STAGE (Weight 8)
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1

2.6 RESETTING UNIT TO ZERO

While counting, the reset line (terminal L) must be clamped at 0 volts. Applying a 1 microsecond, -10 volt pulse to terminal L of the DCU will effect reset. The reset voltage can be generated either electronically by transistor circuitry or mechanically through relay contacts.

SECTION 3

CIRCUITS

3.1 THE BINARIES

The decimal counting unit consists of four binaries, each comprising a pair of PNP transistors, connected in a scale-of-ten circuit. The binaries have two stable states and are alternately triggered from one state to the other by successive pulses. Transistors Q3 and Q10 are emiiter followers to isolate the first and fourth binaries, respectively, from their ac load.

In a PNP transistor, the input impedance is low (in the order of a thousand ohms) when the base potential is negative. This low input impedance permits a base current to flow and the transistor conducts. On the other hand, a positive base potential results in a high input impedance (several hundred thousand ohms). Therefore, no base current flows and the transistor is cut off.

Assume, for example, that the first binary on the schematic diagram is initially in the "zero" state. In this state, Q2 is conducting while Q1 is cut off. A positive input pulse applied through diode CR5 to the base of Q2 drives this transistor to cutoff.

The pulse applied to CR5 is also applied to CR3, but does not affect the state of Q1 since this transistor is already cut off.

As the load current in Q2 decreases, its collector potential approaches -6 volts. This change in voltage level, coupled through resistor R5 and capacitor C3 to the base of transistor Q1, drives Q1 into the active region. As a result, Q1 begins to conduct, and the amplified current flowing through R1 causes the collector potential to fall to almost zero. Under these conditions the diode base clamp CR6 with divider network R2 and R6 maintains a positive potential at the base of Q2 to keep it cut off.

The binary, now in the "one state, remains in this stable state until the next positive input pulse arrives. At that time, Q1 cuts off, Q2 conducts, and the binary resumes its original state.

The collector of each "normally off" transistor in the four binaries connects to a corresponding terminal of the DCU connector. Thus, the change in voltage level at each collector, as the binary changes state, is available as an output signal. The change in voltage level at the collector of each "normally on" transistor is used as the drive signal to the next binary. Therefore, each binary in the DCU reverses state for every two reversals of the preceding binary.

3.2 THE SCALE-OF-TEN CIRCUIT

The scale-of-ten circuit used in the Model 872 DCU is a four-place binary counter wired so that it resets to zero on every tenth input pulse. Operation is explained in detail in the following paragraphs.

3.2.1 Initial Conditions and Circuit Fundamentals

Under initial conditions, transistors Q2, Q5, Q7, and Q9 are saturated. Transistors Q1, Q4, Q6, and Q8 are cut off. These conditions define the "zero" state for each binary.

At this point, a review of transistor binary (flip-flop) circuit fundamentals may be helpful in understanding the circuit description in the following paragraphs.

Consider the first binary, comprising transistors Q1 and Q2. Under initial conditions, Q1 is cut off and Q2 is saturated. Q1 is held at cut-off by divider network R3, R5, and clamp CR2. A positive input pulse applied at the junction of CR3 and CR5 has no effect on Q1, since it is already cut off. While Q2 is saturated, its collector is near ground potential. Now, when the positive input pulse is applied through CR5 to the base of Q2 it drives Q2 into cutoff and the collector potential of Q2 rises to approximately -6 volts. This negative transient, coupled to the base of Q1 through crossover network R5 and C3, drives Q1 into saturation.

Thus, on the first input pulse, the first binary flips and its transistors reverse their states. But the second binary is not affected, since it takes a positive output pulse coupled through emitter follower Q3 from the first binary to cause the second binary to flip.

But on application of the second input pulse, circuit action produces a positive output signal to flip the second binary as follows: the positive input pulse goes through CR3 to the base of Q1 to cut it off. As Q1 cuts off, its collector potential rises to approximately -6 volts. This negative transient couples to the base of Q2 through crossover network R2 and C1 driving it into saturation. When Q2 saturates, the collector potential goes from approximately -6 volts to approximately -0.2 volt. This positive-going pulse passes through emitter follower Q3 to trigger the second binary. To summarize: a positive pulse applied to the first binary will cut off the saturated transistor and regenerative action will drive the cut-off transistor into saturation. The first binary will produce a driving pulse to the second binary only when the second transistor of the first binary goes from cutoff to saturation. Thus, the first binary will produce an output pulse only on every second input pulse, even though every input pulse will reverse the state of the binary. These principles apply to all of the binaries.

3.2.2 Sequence of Operation

Pulse No.	Action
1	First binary flips. Q2 turns off. No output signal.
2	First binary flips. Q2 saturates. Output pulse coupled through Q3 flips second binary. Q5 turns off.
3	First binary flips. Q2 turns off. No output signal.
4	First binary flips. Q2 saturates. Output pulse from Q2 flips second binary. Q5 saturates. Output pulse from Q5 flips third binary and Q7 cuts off.
5	First binary flips. Q2 turns off. No output signal.
6	First binary flips. Q2 saturates. Output signal from Q2 flips second binary. Q5 turns off. No output pulse from Q4.
7	First binary flips. No output from Q2.
8	First binary flips. Q2 saturates. Output pulse from Q2 flips second binary. Q5 saturates. Output pulse from Q5 flips third binary. Q7 saturates. Output pulse from Q7 flips fourth binary. Q9 cuts off. Negative 6.5 volts at collector of Q9 is applied to CR9 and CR11 closing the gate.
9	First binary flips. No output from Q2.
10	First binary flips. Q2 saturates. Output signal from Q2 is blocked from the second binary by closed gate CR9 and CR11. So it goes through C15 and CR21 to flip the fourth binary. Q9 saturates. The output pulse from Q9 goes through emitter follower Q10 to DCU output pin R.

3.2.3 Summary

At the tenth input pulse, all four binaries are in the "zero" state and the DCU is ready for the next counting cycle. The positive output signal from transistor Q10, produced when the counter goes from nine to zero, can be used to drive a Model 862, 860, or 850 DCU. Thus, the counter will supply one input pulse to the next DCU for every ten counts registered.

The number of counts registered by the DCU is represented in binary-coded decimal form by the potentials on the readout lines of the binaries.

The reset line connects through a corresponding resistor to the base of the normally-on transistors (Q2, Q5, Q7, and Q9) in each binary. A negative voltage pulse to the reset line will cause the normally-on transistors to conduct and thus trigger all binaries to the zero state.

3.3 THE GATE CIRCUIT

The gate circuit, consisting of diodes CR24 and CR4, allows the Model 872 DCU to be controlled by an external current source to inhibit counting. With a dc current of 30 ma flowing from pin C, for example, the pulse source driving the input (pin A) would be required to supply 30 ma more than was originally needed to trigger the first binary. This high threshold level thus inhibits counting for all but extremely high current pulses.

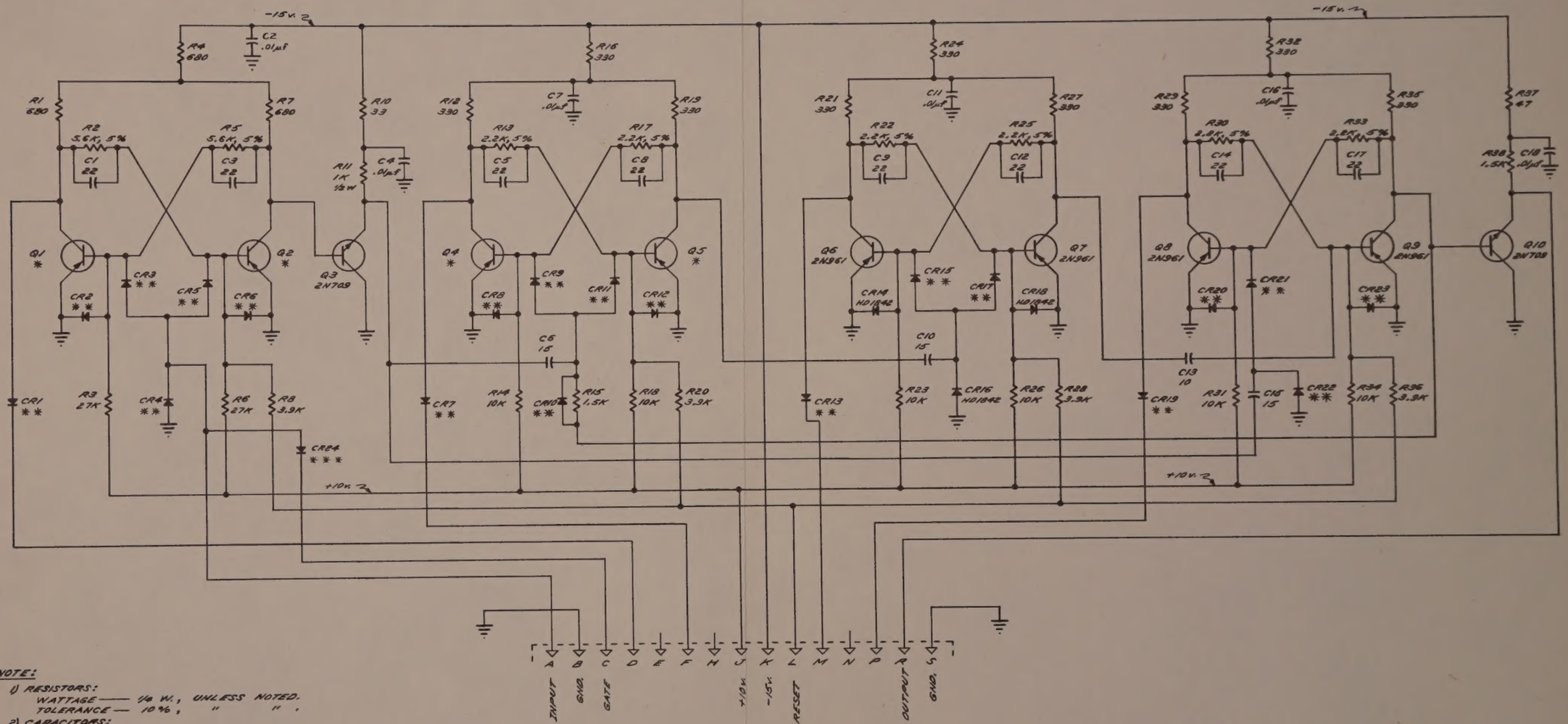
SECTION 4

PARTS LIST

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
C1	637-824008	Capacitor, F. Mica, 22pf, 300V, 5%	8
C2	633-804717	Capacitor, F. Cerm., 0.01μf, 500V, -20% +80%	6
C3		Same as C1	
C4		Same as C2	
C5		Same as C1	
C6	637-824006	Capacitor, F. Mica, 15pf, 300V, 5%	3
C7		Same as C2	
C8 & C9		Same as C1	
C10		Same as C6	
C11		Same as C2	
C12		Same as C1	
C13	637-824004	Capacitor, F. Mica, 10pf, 300V, 5%	1
C14		Same as C1	
C15		Same as C6	
C16		Same as C2	
C17		Same as C1	
C18		Same as C2	
CR1	755-817250	Diode, Germanium, 6 PIV, 200ma, 1V min. fwd.	20
CR2 thru CR13		Same as CR1	
CR14	755-824300	Diode, Germanium, type HD1842	3
CR15		Same as CR1	
CR16		Same as CR14	

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
CR17		Same as CR1	
CR18		Same as CR14	
CR19 thru CR23		Same as CR1	
CR24	755-815561	Diode, Silicon, 75 PIV, 10ma, 1V min. fwd.	1
Q1	755-417294	Transistor, special	4
Q2		Same as Q1	
Q3	755-819906	Transistor, Silicon, NPN, 300mw	2
Q4 & Q5		Same as Q1	
Q6	755-817811	Transistor, Germanium, PNP, 150mw	4
Q7 thru Q9		Same as Q6	
Q10		Same as Q3	
R1	601-823937	Resistor, F. Comp., 680Ω, 1/4W, 10%	3
R2	601-822397	Resistor, F. Comp., 5.6K, 1/4W, 5%	2
R3	601-823949	Resistor, F. Comp., 27K, 1/4W, 10%	2
R4		Same as R1	
R5		Same as R2	
R6		Same as R3	
R7		Same as R1	
R8	601-823943	Resistor, F. Comp., 3.9K, 1/4W, 10%	4
R10	601-823923	Resistor, F. Comp., 33Ω, 1/4W, 10%	1
R11	601-008076	Resistor, F. Comp., 1K, 1/2W, 10%	1
R12	601-823935	Resistor, F. Comp., 330Ω, 1/4W, 10%	9
R13	601-822328	Resistor, F. Comp., 2.2K, 1/4W, 5%	6
R14	601-823108	Resistor, F. Comp., 10K, 1/4W, 10%	6
R15	601-823112	Resistor, F. Comp., 1.5K, 1/4W, 10%	2
R16		Same as R12	

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
R17		Same as R13	
R18		Same as R14	
R19		Same as R12	
R20		Same as R8	
R21		Same as R12	
R22		Same as R13	
R23		Same as R14	
R24		Same as R12	
R25		Same as R13	
R26		Same as R14	
R27		Same as R12	
R28		Same as R8	
R29		Same as R12	
R30		Same as R13	
R31		Same as R14	
R32		Same as R12	
R33		Same as R13	
R34		Same as R14	
R35		Same as R12	
R36		Same as R8	
R37	601-823925	Resistor, F. Comp., 47Ω, 1/4W, 10%	1
R38		Same as R15	
	864-412958	Pad, Transistor	10



NOTE:

1) RESISTORS:
   WATTAGE —— 1/8 W., UNLESS NOTED.
   TOLERANCE — 10%, " "
2) CAPACITORS:
   CAPACITY —— IN P.F., " "
   VOLTAGE —— 300v., " "
   TOLERANCE — 5%, " "
3) .01µF DISC ARE -20+80%, 500v.
4) * — TRANSISTORS ARE TO BECKMAN SPEC. DWG. A755-411294
5) ** — DIODES ARE TO BECKMAN PART Nº 755-817250.
6) *** — DIODE TO BECKMAN SPEC. PART Nº 755-815561.